COUPLED SIMULATIONS OF CONVECTIVE BURNING OF STATIONARY AND PROPAGATING CRACKS IN AN ENERGETIC MATERIAL

L. Massa [a], **C. Hwang** [b], **P. H. Geubelle**[a] and **R. Fiedler** [a]

[a]Center for the Simulation of Advanced Rockets
University of Illinois at Urbana-Champaign
1101 W. Springfield Ave., Urbana IL, 61801
luca1@uiuc.edu, geubelle@uiuc.edu, rfiedler@uiuc.edu

[b]Research Department, American Bureau of Shipping
16855 Northchase Dr., Huston TX, 77060
hwang12_uiuc@yahoo.com

In recent years a considerable amount of research has been dedicated to the area of computational simulations of solid propellant combustion. One of the most distinctive feature of solid propellant combustion is the presence of a granular, heterogeneous material which is subjected to an increasingly large loading and exposed to a high temperature fluid. In this environment cracks form and propagate. When a crack is formed, heat is spread in the cavity primarily by convection, from which the name of convective burning, and new ignition fronts are created as the propellant reaches a critical temperature value. The extra mass injected, product of the pyrolyzation of the solid over the augmented burning surface, drives the pressurization and in this way dynamic and fractural mechanic effects are enhanced. In order to investigate the effect of different parameters on flame spreading and crack propagation we have developed a theoretical model in which combustion, fluid-mechanic and solid-mechanic issues are considered. The result is a fully integrated numerical code of which the fundamental ingredients are: a cohesive/volumetric finite element scheme, a two dimensional Euler solver with mesh adaptivity capability, and a dynamic combustion model. We apply this algorithm to a set of simplified geometries that typify cracks in solid propellant, under realistic loading conditions. Our simulations show the importance of the coupling of mechanical deformation in the solid and convective transport in the fluid, the presence of gap closure when the crack aspect ratio (length/width) is large enough, and the effect of the interaction between advancing burning front and propagating crack.